carbonate. As a result, sodium hydrogen carbonate can be separated out of the solution by precipitation. This separation by solubility allows the $NaHCO_3$ to be separated and sold as baking soda, or to be decomposed into Na_2CO_3 as washing soda.

The ingenuity of Solvay's design becomes apparent when you write out the reactions and see that all of the intermediate products are recycled as reactants in other reactions. Nothing is left as a by-product except calcium chloride, which today is sold as road salt and as a drying agent (desiccant). See for yourself in the following questions.

Exercise

26. Write and balance the reaction equations for the Solvay process from the word equations below.
    (a) Limestone, $CaCO_{3(s)}$, is decomposed by heat to form calcium oxide (lime) and carbon dioxide.
    (b) Carbon dioxide reacts with aqueous ammonia and water to form aqueous ammonium hydrogen carbonate.
    (c) In the same vessel, the aqueous ammonium hydrogen carbonate reacts with brine, $NaCl_{(aq)}$, to produce aqueous ammonium chloride and solid baking soda, $NaHCO_{3(s)}$.
    (d) Heating the separated baking soda decomposes it into solid washing soda, water vapor, and carbon dioxide.
    (e) The first of two recycling reactions involves the reaction of lime ($CaO_{(s)}$) with water to produce slaked lime ($Ca(OH)_{2(s)}$).
    (f) Next, the slaked lime is added to the aqueous ammonium chloride (an intermediate product) to produce ammonia, aqueous calcium chloride, and water.
    (g) Write the net reaction for the Solvay process (page 237).
27. *Intermediates* are produced part way through a process and become reactants in a later reaction. Cross out all intermediate products in the reaction equations you have written. Do not be concerned about quantities of reactants and products. What you have left should combine to give you the net unbalanced reaction for the Solvay process.
28. *Raw materials* are the materials that are consumed in the net (overall) reaction. What are the raw materials for the Solvay process? Where are these raw materials obtained? What makes these materials suitable for a large-scale chemical process?
29. The *primary products* and the *by-products* of a chemical process depend on how marketable the products are. What are the primary product and by-product of the Solvay process?
30. What intermediate in the Solvay process is highly marketable? What are some consequences of removing this intermediate from the system of reactions?
31. Resources other than chemical and technological resources are required for most chemical processes. What additional natural resources are needed for the Solvay process?
32. (Discussion) What makes the Solvay process so economical?